maximum deposition forming the thickest mass (58,000 feet) of Pliocene in North America. The mountains of British Columbia are believed to have been at a higher level than now, as it is supposed that Vancouver and Queen Charlotte Islands probably formed part of the mainland.

At or near the close of the Pliocene the Sierra Nevada increased in height by the tilting of the whole block westward. New river valleys, cut through the late basalt sheets of the Sierras, are much deeper than the older valleys excavated in Cretaceous and Tertiary times, owing to the greater height of the mountains and to the consequent greater fall of the streams. At this time the Wasatch Mountains and high plateaus of Utah and Arizona were again upraised, and the great mountain barrier of the St. Elias, in southeastern Alaska, was likewise thrown up. At this time also, or perhaps later, the mountains of British Columbia were probably raised still higher.* It will be seen from this that the present topography of the western border of our continent including Central America and the Isthmus of Panama belongs to a new topographic era, and fully substantiates the view that the fauna of these regions is very recent compared with that of the Atlantic border, and that the number of nascent or incipient species is much greater.

Alpheus S. Packard.
Brown University.

(*To be concluded.*)

Journal Geol., IV., pp. 882, 894, 897 and 898. (Quoted from Drake.)

EARTHQUAKES.

Commandant Montessus de Ballore, of the French Army, is well known as an authority on earthquakes in general, and especially on the earthquakes of Central America, where he resided for a considerable time some dozen years ago. Besides his own observations he has discussed thousands of others, collected by himself or taken from the extended lists of Mallet (B. C. 1606 to A. D. 1850), Perrey, Fuchs, etc. All of the available material has been sifted and examined, and then discussed in a scientific fashion, to bring out whatever general laws may underlie the statistics.

A collection of some of M. Montessus' pamphlets has lately come into my hands.* They deserve anextended review, but, failing this, the following notes may be of interest.

The relations between the topography of a country—its topographic relief—and the frequency of its earthquakes has been deduced from 98,868 records of shocks at 6,789 centers distributed in 353 regions of the globe. The most general statements that can be made are as follows:

"Regions of great earthquake frequency lie near the greater lines of corrugation of the earth's crust."

"In any group of adjacent seismic regions the earthquake frequency is greatest in the regions of highest relief."

These very general laws may be put into more special forms that are directly proved by the statistics:

I. Mountainous regions are more unstable than plains.

II. Sea-coasts near oceans that rapidly deepen, especially such as are bordered by high mountains, are more unstable than the coasts of shallow seas, especially if such coasts have no mountains near them.

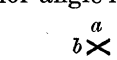
III. The shorter and steeper slopes of mountain chains are the more unstable.

* Relations entre le relief et la sismicité, *Archives des Sciences Phys. et Nat.*, 1895; Le Japon sismique, *ibid.*, 1897; Les Etats-unis sismiques, *ibid.*, 1898; Les Indes Neérlandaises sismiques, *Nat. Tijd. der Kon. Nat. Ver. in Nederlandsch—Indie*, Dl. LVI., 1896; Etude critique des lois de répartion saisonnière des séismes, *Mem. de la Soc. "Alzate,"* tomo IV.; Relation entre la fréquence des tremblements de terre et leur intensité, *Bull. d. Soc. Sismologica Ital.*, Vol. III.; La peninsula ibérica séismica y sur colonias, *Ann. de la Soc. Española de Hist. Nat.*, tomo XXIII.; Seismic Phenomena of the British Empire, *Quar. Jour. Geol. Soc.*, Vol. LII., 1896.

IV. The unstable flank of a mountain chain is most unstable in its steepest parts.

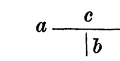
V. The steeper sides of valleys are, likewise, the more unstable.

VI. When two mountain chains cross, making an angle of less than 90°, the area inside the exterior angle is the most unstable.



(The region *a* will have more shocks than the region *b*.)

VII. When a mountain chain (*a*) has a buttress (*b*) the flank opposite *b* is the more unstable (*c*).



VIII. Mountain masses are more unstable on their flanks than within the mass.

IX. Abrupt changes of slope are especially favorable to instability.

X. The highest parts of valleys are frequently more stable than those at the average level, and the lowest parts are generally more stable than those of average level.

XI. Narrow mountainous peninsulas are unstable.

XII. An isthmus in a sunken region is unstable.

XIII. Narrow straits are often the centers of earthquakes.

XIV. Regions of great earthquake frequency usually do not coincide with regions of many volcanoes; or, earthquakes and volcanic phenomena are, in general, independent of each other.

Several of these laws are well known; some of them would be announced by an expert even before seeing the data; but, on the other hand, some of them are genuine surprises. In their collected shape they constitute an important contribution to the subject. Law XIV. is not proved in the pamphlets cited by title, but the first half of it is well known to be true in very many regions of the globe, and the last half follows as a *statistical* consequence.

It is a very ancient opinion that earthquakes are decidedly more frequent at some seasons of the year than at others. Aristotle, for example, declared that the autumn and spring were seasons of frequent shocks, while summer and winter were seasons of few shocks. Perrey, Mallet and others have announced similar laws. From a discussion of 63,555 shocks in 309 regions of the globe M. de Montessus shows that, taking the whole earth together, shocks are equally probable at any season. This general law may not be true for certain special localities, but it is true for the whole earth.

In order to study earthquake statistics to advantage and to compare one region with another it is desirable to have some uniform method of expressing earthquake frequency numerically—of deducing the coefficient of earthquake frequency, as a mathematician might express it. M. Montessus forms such numbers in the following way: The region to be studied is divided into smaller areas. Each of these areas is chosen so as to be fairly homogeneous in physical characteristics, geographically, geologically, etc. The areas are now divided into as many small squares as there are earthquakes per year. The greater the frequency the greater the number of squares, of course. The side of one of these small squares is chosen as the coefficient of frequency,* and the greater the number of shocks per year the smaller is this coefficient. There is something arbitrary in this process; but, at the same time, it leads to results of importance because, after all, it is only the *relative* earthquake frequency that is sought, not the absolute. Of two regions, which is most shaken and in what ratio? is the question to be solved.

In eastern Java, for example, *S* (the seismic number) is equal to 56 kilometres. That is, there is, on the average, one earthquake per year in each square of 56 kilometres on

* M. Montessus calls it the 'sismicité.'

a side. In western Java $S = 50$ km. There are more earthquakes in this region. It will not be without interest to quote a few of the author's conclusions expressed in this numerical form.

For Porto Rico, $S = 2.3$ km., that is, there is one earthquake annually in each square of 2.3 km. (1.38 miles) on a side on the average.

For the island of Luzon, $S = 2.8$ km.; for Manila, $S = 3.0$ km.; for central Cuba, $S = 41$ km.; for western Cuba, $S = 128$ km.; for Hawaii, $S = 37$ km. These numbers may be compared with others relating to the United States, as central California, $S = 76$ km.; New England, $S = 90$ km.; the Carolinas, $S = 313$ km.; Michigan, $S = 487$ km., or with Tokyo, Japan—one of the most disturbed portions of the globe—for which the number is 12 km. Manila and Porto Rico are far more disturbed than this.

Work of the kind here noticed is valuable in proportion to the care with which the data have been sifted, and to the impartiality of the investigator. It is believed that anyone who will examine the work of M. Montessus carefully will conclude that he has made a considerable step forward.

Edward S. Holden.

Stockbridge, Mass.,
August 15, 1898.

ZOOLOGICAL NOTES.

Mr. Frank Finn, of the Indian Museum, Calcutta, has been making an extensive series of experiments with birds in regard to the value of the so-called warning colors of butterflies. These experiments, which are recorded at length in the *Journal* of the Asiatic Society, are extremely valuable from the fact that while it has been assumed that insects nauseous to man are equally nauseous to birds this has not been sufficiently well proved. In fact, it has been shown by the investigations of the Department of Agriculture that many of the (to us) vile-tasted Hemiptera are greedily devoured by birds. Definite information is also needed as to the extent to which birds actually eat butterflies. The experiments were mainly made with Babblers, *Crateropus*, and Bulbuls, *Otocampsa*, although a few other species were used.

As a result of his experiments Mr. Finn concludes: "That there is a general appetite for butterflies among insectivorous birds, even though they are rarely seen when wild to attack them.

"That many, probably most, species dislike, if not intensely, at any rate in comparison with other butterflies, the 'warningly-colored' *Danainæ*, *Acræa violæ*, *Delias eu charis* and *Papilio aristolochiæ*, of these the last being the most distasteful, and the *Danainæ* the least so.

"That the mimics of these are at any rate relatively palatable, and that the mimicry is commonly effectual under natural conditions. That each bird has to acquire separately its experience, and well remembers what it has learned."

That, therefore, on the whole the theory of Wallace and Bates is supported by the facts and Professor Poulton's suggestion that animals may be forced by hunger to eat unpalatable forms is also more than confirmed.

F. A. Lucas.

CURRENT NOTES ON ANTHROPOLOGY.

INDETERMINATE FORMS OF CHIPPED STONES.

There is a large class of objects which constantly puzzle the antiquary. These are flaked or chipped stones simulating the forms of art effects, yet not positively indicating the work of man.

In a handsome and abundantly illustrated volume of 70 pages M. A. Thieulen publishes a paper read before the Anthropological Society of Paris on a collection of